

THE SHAPE OF THINGS TO COME

Address by

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Following the first supersonic flight in 1947, flight speeds have been pushed to two, three, six--and then, suddenly--25 times the speed of sound.

To the casual observer, all the problems in aeronautics were solved, and aeronautical scientists and technicians began directing their efforts toward the space flights of the future.

But is this true? And in the context of the shape of things to come, where are we going in the future?

I will confine my remarks this afternoon to the more familiar aspects of aeronautics, as the term is commonly understood. Even in this now seemingly limited and older area of activity there are both new frontiers of technology and important long-term problems still remaining to be solved.

Traditionally, the main frontier of aeronautics has been performance. Aeronautical scientists and engineers have always sought to increase the speed and altitudes of flight. Supersonic flight of military aircraft has become almost commonplace, and the quest continues for still greater speeds. In anticipation of further advances in the performance of aircraft, the X-15 research airplane is now systematically exploring the problems of flight at these higher speeds and altitudes, and records have been broken consistently.

However, let's think for a moment of where we are today.

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The military pilot can fly at about twice the speed of sound at considerable expense.

In civil aviation, the sonic barrier has not yet been penetrated. The man-in-the-street is limited to travelling at about 600 miles per hour; there are millions of people who have yet to experience flight at all. Also, scheduled flights are often delayed, diverted at destination, or cancelled because of weather.

I don't think this is the ultimate in transportation! In the present space era there is all too often a tendency to assume that progress in aeronautics has reached an end.

Actually we are on the threshold of aeronautical advances which will revolutionize travel as we know it today.

The point I am making is that the frontier in aeronautics is changing. The X-15 has flown out of the top of the atmosphere and exceeded 4,000 miles per hour. The era of speed-and-altitude-records is on the wane and we are getting on with the job of providing aircraft that will do the workhorse job of making the earth a better place to live for all people. Developing an efficient world-wide transportation system is certainly important and a most formidable challenge to achieve. "Better Transportation" is really another way of saying "Better Communication" and better communication leads to better understanding between people and nations.

What do we see today in the research laboratory that will lead to new developments that can help us achieve our objectives?

First, I would like to tell you about some fundamental work that has been going on that I think will be extremely important to aeronautical development--wing-variable sweep.

Today, all operational aircraft that fly at supersonic speeds are not as efficient as they could be, either at supersonic speed, or at subsonic speed where they must do considerable flying and maneuvering--after all they have to take-off and land as well as have efficient performance while awaiting clearance to land--good subsonic characteristics would permit supersonic aircraft to use shorter runways and utilize steeper climb angles thus alleviating the noise problem near airports by putting the source of the noise

at higher altitude and further away from the people on the ground at any given point.

Now, the requirement to fly at supersonic speeds and subsonic speeds presents an aircraft designer with a dilemma--he must try to marry the conflicting design requirements of two speed regimes. The optimum supersonic airplane is long and slender with thin short wings that are highly swept back--compared to its supersonic brother the low speed subsonic airplane is short and fat with long wings with little sweep--it is almost "East is East and West is West and n'er the twain shall meet."

It would be most convenient if we had the power to change the laws of nature, perhaps to triple or quadruple the speed of sound; but not having been given such powers, we must seek to make the aircraft compatible with the flow laws and this obviously means variable geometry.

Variable geometry is not new--retractable landing gears and wing flaps are a form of variable geometry. Variable wing--sweep is not new either. We have had the X-5 research aircraft and the F10F experimental aircraft both with wings that could be swept and unswept in flight. Both of these aircraft were active in flight programs in the early 1950's. The variable geometry worked in flight. The X-5 aircraft was in fact used as a chase airplane after the research phases were concluded. Since that time, through aerodynamic research, a new approach has been discovered that makes variable geometry very attractive so that we can see now the lines of attack on the problem of developing efficient subsonic/supersonic aircraft. If this design concept can be exploited, advances in the performance and versatility of aircraft would be similar in magnitude to those following the introduction of the jet engine.

Now let us look at the supersonic transport.

Today's jet transports are regularly carrying passengers to their destinations in little more than half the time required a few years ago. Our understanding of aerodynamics has reached the point where it appears certain that in time an efficient supersonic transport can be developed. The need for a commercially competitive supersonic transport is evident. The major advances in transportation have always been associated with increases in speed. To continue the free-world's domination of international airways there is no

alternative but to forge ahead. There is no question as to whether there will be a supersonic transport; the only question is whose. Right now part of my job is to see that the United States is the first to develop a commercially competitive supersonic transport--I strongly suspect some of you represent other countries with a similar objective.

There are a host of problems in need of solution relative to the supersonic transport; a new engine is needed; aerodynamic efficiency must be improved; structures and materials must be developed; dynamic stability and control problems must be defined and solutions found; and there is the noise and sonic boom problem, and air traffic control.

Economic and social problems attendant upon introducing supersonic transports in service must also be weighed carefully. All of us are familiar, for example, with the noise problem as it exists today. And we are becoming more and more concerned over the need for balance between the performance of the airplane and the cost and efficiency of other parts of the total air transportation system, such as airports, air traffic control, transport from airport to city terminal, and so forth. As the performance of the airplane mounts, these problems all become more acute, and entirely new problems are introduced.

Such considerations should not lead us to throw up our hands and abandon real efforts toward further progress, however. It simply means we must work harder.

Now I would like to briefly discuss the next high performance frontier in aeronautics--hypersonic flight.

We can define the hypersonic airplane as a machine that flies faster than one mile per second or 3600 miles per hour. (Mach 5.5). There is interest in this flight regime for several basic reasons:

For future hypersonic transports and manned bombers.

Also, reentry from space is a hypersonic problem.

There is a great economic incentive to develop recoverable hypersonic airbreathing boosters and thereby replace the brute strength approach.

One step beyond is to take the recoverable booster all the way to orbit. This is referred to in the literature as "Space Plane." Its propulsion system may be either pure rocket, air-breathing, or a combination of both.

The basic airframe problem of hypersonic flight is the high temperature resulting from aerodynamic heating.

The aerodynamic heating problem has top priority in our research programs and has already led to new concepts of aerodynamic design and the development of cooled structures and refractory and ablative materials. It can be stated that sustained hypersonic flight appears practicable and that a new aeronautical era of almost unlimited speed potential lies before us.

In the hypersonic region, the X-15 has given tremendous focus to our efforts. It is a truly remarkable airplane. As you know, it has already exceeded 4,000 miles an hour, and over 300,000 feet altitude.

The X-15 has such capability that it will be used in furthering certain space research programs. Already we are making radiation measurements--piggy-back experiments along with the hypersonic research program. Our results with the X-15 have been so encouraging that I think we must soon look beyond the transport that goes to Mach 2 or 3, and begin laying the groundwork for the generation to follow.

Let us now look at the other end of the speed spectrum--V/STOL aircraft.

Why all the current interest in V/STOL aircraft? I believe the interest stems from the real necessity to "Take-to-the air" to prevent the eventual strangulation of our urban areas; to provide the short and medium range transportation that will make the terminal-to-terminal time saved by the jet transports, and by the future supersonic transport, a real "Door-to-Door" saving; and to open up undeveloped countries and remote austere areas which may be rich in natural resources.

Now I'm just an engineer--a product of a glorified trade school--so I may be on thin ice--but to my way of thinking, the destiny of a nation of a people depends on its

natural resources and, in the broader picture, our survival on earth depends on what comes out of the ground whether it be minerals, fuel, or food and water. Great strides have been made in agriculture in increasing land productivity and more progress will be made. As a result more and more people can be fed by fewer and fewer agricultural producers. Medicine is keeping people alive longer. The U.S. Bureau of Census predicts that three-fourths of the people in the U.S. will be living in congested areas by 1970. These people will have to move about and will have to be provided with all the essentials and luxuries of good living. We have to develop a better method of transportation than conventional surface transport which requires expensive highways.

There is also the problem of dispersing passengers and cargo to their ultimate destination from conventional airports after arrival in large long/range transports. Short take-off and landing vehicles capable of operation in crosswinds could be operated at the corners of the airport, away from the runways used by the major trunk airlines. Such aircraft should not enter or leave the airport area in the same direction as the major trunks. If approach speeds are made adequately low, interference with departure and arrival of the trunk lines would be kept to a minimum. Airports such as Chicago's Midway, which are in the center of built-up metropolitan areas (which by-the-way appears to be the eventual fate of all airports) and consequently plagued by noise and flight hazard complaints, may be able to continue operation by using short take-off and landing transports which can make very steep climb-outs and landing approaches and thereby alleviate both the noise and flight hazards.

Another exciting prospect is what we call the bush transport--the simple rugged cargo plane that operates out of small jungle clearings and improvised landing strips. Canada's Caribou and Otter airplanes are examples of this type of aircraft. France's Breguet 941 is another excellent example.

I have long believed the great potential of aviation is in future world development. Senator Mike Monroney of Oklahoma, Chairman of the U.S. Senate Aviation Committee and one of our nation's leading aviation authorities, recently had this unsolicited advice for underdeveloped nations who plan a transportation system. He said, "Countries should realize the great advantage of skipping the highway and

railroad age, and going directly from the buffalo cart into the air-age for connecting their country."

Here, then, is a challenge to technology and the aircraft industry of the free world, to provide not only the aerial truck but the total aeronautical leadership that is so sorely needed at the present time. And in the process we may solve some of our own problems relative to the short-haul transport and find the much discussed replacement for the DC-3.

What is on the horizon in the way of vehicles to fulfill these requirements?

There are many design concepts--the helicopter, the tilt rotor; tiltins propellor; tilt wing; lifting fan; deflected jet. The deflected-jet type vehicle is typified by the British Hawker P-1127. Other types I could mention include the dual-propulsion vehicles, such as the Fairey Rotodyne; and the Tail Sitters.

Of the vehicle types I have mentioned, only the helicopter is in operational use. All the others are test-beds being flown to define the problems and establish the advantages and disadvantages inherent in the various concepts.

Now, no efficient transportation system can have in it so many varieties of vehicles. The order in which I mentioned the concepts was not haphazard--in general as we proceed from the helicopter to the jet-powered machines we advance in speed performance but decrease in hovering capability, i.e., the helicopter can hover the longest period of time for a given amount of fuel, other things being equal. Therefore, where a hovering capability is required the helicopter is the machine to use. Also, because of noise restrictions, helicopters could be the only form of vertical take-off and landing aircraft suitable for operation from the center of cities. However, the helicopter has problems--commercial helicopter operations are heavily subsidized and yet in spite of the subsidy commercial helicopter operations are not expanding as they should, because the travelling public is relying on the more reliable all-weather surface vehicles. To provide all-weather capability the helicopter must have improved flying and handling qualities and stability characteristics. The hubs and rotors must be simplified to reduce maintenance costs. There has not been enough emphasis on making helicopters more efficient. The helicopter is a unique lifting machine and

we should accept the idea that a cruising speed of 60-80 knots is all that is needed to provide faster service than surface transportation and thus reduce the magnitude of many of its problems. I think those of us who are in the technical field must accept the blame for keeping helicopter operations in the state they are. I suggest that we should address ourselves to the solution of the problems that the commercial operators can define for us and also, that the commercial operators examine their operation to define the technical advances that would relieve the need for subsidies.

Of the other types of vehicles; where high performance is a requirement, the jet-powered or fan machines are the most promising. Between the helicopter and the jet machines are many types and it is not clear at the present time which concepts will fill the bill for medium range, moderate speed, transports. However, research now underway, and operational experience, will define this vehicle.

There are other vehicles that operate in the low speed range which should be mentioned because they have potential as special-use machines, for example, the aerial jeeps, ground-effect machines, coleopters, the flying platform, and the parawing.

I won't discuss all these types but I would like to spend a minute on the parawing, or paraglider, as it is sometimes called, which has evolved out of a hobby of Mr. Francis Rogallo, an aeronautical research scientist at our Langley Research Center.

In the early 40's, Mr. Rogallo developed a very simple toy kite made of thin mylar plastic, that is practically indestructible compared to the conventional paper and stick kite. It flies so well that even an adult can fly it. The paraglider is not much more than a large kite. Its main claim to fame is its utter simplicity, and low cost. It can be folded and packaged like a parachute but unlike the parachute, it can glide and is highly maneuverable. Control is obtained by simple reefing of the shroud lines. Its potential applications are almost infinite. It has been deployed and "flown" at supersonic speeds in wind tunnels, and is being considered for rocket booster recovery and space craft recovery. A piloted version is currently in flight test. Additionally, it shows promise for many aircraft applications such as range extension for helicopters or enabling conventional aircraft to get in or out of short fields.



New uses and applications are being proposed constantly as studies continue.

In a short time I have touched upon only a few examples to illustrate the potential of the aeronautics field in various performance regimes.

The frontier in aeronautics extends from the extremely low speed regime of the helicopter to hypersonic speeds.

Viscount Montgomery, several years ago said, "Change is inevitable; progress is not inevitable."

We will see change all around us in the months and years ahead, and if enough good men apply their talents to the task at hand--we will see progress.

I believe that research over the next 10 years will help provide the foundations for the more useful and more versatile aircraft the world requires.

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